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PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) DRYING GAS IN COMPRESSED GAS SYSTEMS

(71) We, HANKISON CORPORATION, a Corporation organized under the laws of the State of Pennsylvania, United States of America, of Canonsburg, Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the drying of compressed gas.

According to the present invention there is provided gas drying apparatus incorporating a container, an inlet for gas to be dried and an outlet for dried gas, a first compartment located within said container between said inlet and outlet to hold desiccant material in the path of the gas flow, a second compartment located within said container downstream of said first compartment and adjacent said outlet, an exhaust valve provided in the container wall upstream of the first compartment, a check valve interconnecting said first and second compartments and adapted to close when said exhaust valve is opened and a passage which by-passes said check valve.

In a preferred embodiment of the invention a filter for removing oil is located within the container upstream of the first compartment and the exhaust valve is operable to discharge explosively compressed gas from within the container to eject oil droplets collected by said filter.

In order that the present invention may be more clearly understood and readily carried into effect, the same will now be described with reference to the accompanying drawings, in which:—

Fig. 1 is a longitudinal section through the apparatus;

Fig. 2 is a top plan view of the apparatus shown in Fig. 1;

Fig. 3 is a section along the lines III-III of Fig. 1;

Fig. 4 is a section along the lines IV-IV of Fig. 1; and

Fig. 5 is a partial longitudinal section of a modification of the apparatus shown in Figs. 1 to 4.

Referring now more particularly to Figs. 1 to 4 inclusive of the drawings, the further embodiment of our drying apparatus as shown therein includes a desiccant container 200, the outlet 202 of which is coupled through conduit 204 and check valve 206 to storage tank 23′. The check valve 206 permits full flow through the conduit 204 from the container 200 to the storage tank 28′, but does not permit any flow whatsoever in the reverse direction. Thus, there is no differential flow control means between the container 200 and the storage tank 28′. Therefore, no compressed fluid can be withdrawn from the storage tank 28′ to the container 200 at any time, as during the regenerative portion of the cycle for regenerating desiccant material 208 contained within the container 200. The apparatus of Figs. 1 to 4 can be employed in conjunction with vehicular brake systems without violation of local codes which prohibit extracting purge or regenerative fluid from the storage tank 28′.

The desiccant container 200 is provided with an inlet 210 for connection to a compressor (not shown in the accompanying drawings but as 10, 51 or 51′ of the systems shown in Figs. 1, 2 and 8 respectively of Applicant's Patent No. 1136052. The container 200 also is provided with a dump or exhaust valve 212 similar to that shown at 33 in Figs. 1 and 3, at 57 in Fig. 2, or at 103 in Fig. 8 respectively of the above-mentioned Patent, and for the same general purposes.

In this arrangement of the invention, the mass of desiccant material 208, which can be one of the materials described in the above-mentioned Patent, is contained within an inner shell or cartridge 214. which is positioned desirably co-axially within the container 200 and spaced inwardly therefrom to form an annular flow passage or plenum 216. With this arrangement, compressed air entering the container 200 through the inlet 210 flows downwardly through the plenum 216 as denoted by flow arrows 218 to the

lower space 220 adjacent a rounded bottom 222 of the container 200. The lower end of the cartridge 214 rests upon the upper reaches of the rounded bottom 222 by means of a plurality of feet 224 spaced around the lower extremity of the cartridge 214, with three such feet 224 being utilized in this arrangement. Between the feet 224, deeply chamferred areas 226 of the lower extremity of the cartridge 214 permit the compressed fluid to flow between the feet 224 as denoted by flow arrows 228, into the bottom plenum area 220 of the container 200. In this example, the rounded bottom 222 serves to position the lower end of the cartridge 214 substantially co-axially of the container 200 to provide the annular flow plenum 216 with a uniform radial dimension.

It will thus be seen that the cartridge or inner shell 214 is replaceable together with a desiccant material 208 and an oil separator 232 described more fully below. In furtherance of this purpose, the cartridge 214 is sealed to the upper end portion of container 200 by a sealing arrangement which also seals the junction between the container 200 and its top closure 221 which is removably secured to the container 200 through joining flanges 223 and 225 respectively. In furtherance of this purpose, a sealing ring 227 is inserted adjacent the inward junction of the flanges 223 and 225 where tightening of bolts 229 compresses the sealing member 227 between the adjacent extremities of the container 200, its closure 221 and the upper end portion of the cartridge 214. Thus, the sealing member 227 seals the closure 221 to the container 200 and at the same time positions the upper end portion of the cartridge 214 co-axially of the container 200, while sealing the upper plenum or purge chamber 242 of the container 200 from the annular plenum 216 between the container 200 and the inner shell or cartridge 214.

From the plenum 220 the compressed fluid flows upwardly through a number of aperture means 230 in oil separator 232, as indicated by flow arrows 231, and through lower filter pad 234 and thence through the desiccant material 208. From the desiccant material 208 the compressed fluid flows upwardly through the upper filter member 236 through an intermediate plenum 238 and thence through a central aperture 246 in domed baffle 240 into an upper plenum 242. From the upper plenum 242 the compressed fluid exits from the container 200 as denoted by flow arrows 244 through outlet 202, conduit 204 and check valve 206 to the storage tank 28′. As pointed out previously, once the compressed fluid is conveyed into the storage tank 28′, it cannot be extracted therefrom to the conduit 204 because of check valve 206. Accordingly, no compressed fluid is returned from the storage tank 28′ to the container 200 for purposes of regenerating the desiccant 208.

The compressed fluid flows through the central flow aperture 246 of baffle 240 as denoted by flow arrow 248. The flow of compressed fluid through the baffle aperture 246 is controlled by reverse bleed check valve 260, the valve closing member 252 of which is provided with a reverse bleed aperture 254. The check valve 260 otherwise is of conventional design and in this arrangement the housing 256 thereover is threaded into container 258, the lower end of which is apertured at 260 and otherwise further constricts the flow opening 246 of the domed baffle 240. The check valve receptacle 258 in this example is secured to the top surface of the baffle 240 as by welding, as viewed in Fig. 3.

In this arrangement, the flow baffle 240 desirably is domed inasmuch as a relatively high pressure differential can exist thereacross when the exhaust valve 212 is opened during the regenerative portions of the operating cycle. Thus, the intermediate plenum 238 at such times, together with the chamber containing the desiccant material 208, is exhausted within a very short time. On the other hand, the upper plenum 242 which serves as an integral purge chamber for the desiccant material 208, is exhausted at a much slower rate owing to the differential flow control feature of the reverse bleed check valve 250. Therefore, within a very short time after opening the exhaust valve 212 substantially the entire compressor outlet pressure will exist across the domed baffle 240.

The volume of dry compressed fluid normally contained within the upper plenum 242 at the end of the compression cycle is sufficient, after bleeding slowly through aperture 254 of the reverse metering check valve 250 and expanded to substantially atmospheric pressure within the chamber containing the desiccant material 208 by exhaust valve 212, to completely regenerate the absorbant material 208.

The upper filter member 236 in this example is slidably mounted within the upper end portion of the cartridge 214 and adjacent the domed flow baffle 240. In a desirable form of the upper filter member 236, a porous filtering pad 262 such as an open-celled polyurethane foam is likewise stretched over an apertured, relatively rigid backing member 264, having a somewhat smaller diameter than the inner diameter of the cartridge shell 214. The filter pad 262 is partially wrapped about the periphery of the back-up plate 264 so that the filter member 236 is closely and slidably fitted within the shell 214. The back-up plate 264 can be constructed from perforated sheet steel or other suitably foraminous structural material.

Desirably, the central region of the back-up plate 264 is not apertured where it engages retaining cup 266 for suitable biasing means such as spring 268. The biasing means 268 urges the slidably mounted upper filter pad 236 downwardly against the desiccant material 208 to apply compression thereto. This compressive action minimizes vibration and attrition of the individual desiccant particles within the desiccant chamber.

The lower filter pad 234 is similarly constructed with the exception that the lower back-up plate 270 can be uniformly perforated as shown and is provided with a depending lip 272 whereby the back-up plate and the filter material 274 stretched thereover is positioned in the cartridge shell 214 with rivets 276 or other suitable fastening means.

Spring retaining cup 266 can be omitted if desired whereupon the lower end of the spring 268 can engage directly the upper surface of the upper back-up plate 264. Use of the spring retaining cup 266, however, serves as a catch basin for any particles of foreign matter which may issue through the reverse bleed check valve 250 during desiccant regeneration when purge flow fluid flows from the purge chamber 242 through the intermediate plenum 238 and thence through the chamber containing the desiccant material 208 as denoted by reverse flow arrows 278.

The cup 266 as shown in Fig. 1 is mounted directly beneath the central flow aperture 246 of the domed baffle 240. The reversed regenerating flow from the purge chamber 242 through the check valve aperture 254 is caused to disperse radially by the presence of the cup 266 so that a portion of the reverse flow is diverted toward the outer periphery of the perforated back-up plate 264. As a result, the entire mass of the material in the chamber containing the desiccant material 208 is exposed to the reverse, regenerative flow from the purging chamber 242.

The oil separator 232, as arranged in accordance with our invention, includes for example a pair of foraminous or, as shown, back-up members 280 and 282 with a relatively thin disc or foraminous or porous material, such as filter paper 284 sandwiched therebetween. The term foraminous as used herein and in the appended claims is inclusive of apertures of uniform or non-uniform sizes, and of porosity such as encountered in the aforementioned filter paper or in finely or coarsely sintered members.

Thus, it is contemplated that a relatively thin, finely sintered filtering member 284 can be sandwiched between relatively thick, coarsely sintered backing members 280 and 282 to provide the necessary structural rigidity of the separator 232. Alternatively, a single, relatively thicker but finely sintered filtering member (not shown) or other finely porous filtering member having requisite structural strength to withstand the anticipated pressure drops thereacross, can be employed without one or both of the backing members 280, 282 as described more fully below.

The back-up members 280, 282 and the filter paper 284 are secured together by a clamp or channeled peripheral retaining member 288 which is shrunk or force-fitted into the lower end portion of the cartridge 214 to securely position the oil separator 232 at a location spaced from the lower filter pad 234. As better shown in Figs. 1 and 4, each of the back-up plates 280, 282 are provided with a relatively large number of apertures, with the respective apertures thereof being desirably in substantial alignment. The imperforate areas of the back-up plates 280, 282 thus provide structural rigidity to the filter paper 284, which would otherwise rupture if substantially larger continuous areas thereof were presented to the incoming compressed fluid (flow arrows 231) and to the explosive discharge of the fluid in cartridge 214 during the initial stage of reactivation. The apertures 230 of the upper back-up member 280 of the oil separator 232 also serve to collect the oil which coalesces on the upper surface of the filter paper 284.

A space 286 between the lower filter pad and the oil separator 232 prevents contact of the lower pad 234 and the desiccant material 208 by the coalesced oil, whose capillarity and wettability otherwise would permit a relatively rapid transfer of the coalesced oil from the separator 232 to the lower filter pad 234.

In the arrangement shown, the filter paper 284 is a resin impregnated filter paper of commercial availability. However ordinary filter paper, thin porous metal sheet or sintered metal, porous plastic material or porous glass can be substituted.

It is contemplated that the filtering member 284 and the back-up members 280 and 282, if used, need not be flat but can take any desired and convenient shape such as conical or cup-shaped, as long as the separator 232 extends entirely across the path of the incoming compressed fluid and of the outgoing exhaust or purge fluid.

Where a somewhat more rigid filter member, such as a sintered member, is used in place of the filter paper 284, the normally downstream back-up member 280 can be omitted where the pressure differential associated with normal, forward flow of compressed fluid (flow arrows 231) are not severe. Where a sintered structural material such as sintered bronze, stainless steel or carbon is employed for the filter member comprising the separator 232, both back-up members can be omitted.

Bypassing of the filter member or disc 284

is prevented by a tightly fitted engagement between the channel retaining ring 288 and the adjacent inner wall portion of the cartridge 214. Since in most compressed fluid systems the contaminating oil exists in the system as a mist of microscopic dimensions, a surface type filter with minute pore size, such as that shown at 284 in Fig. 1, is required to coalesce the oil mist. The use of a surface type filter permits the oil separator 232 to be periodically regenerated by high volume flow reversals, in contrast to the use of a depth type filter.

In order to ensure complete purging and regeneration of the soil separator 232, the latter in this example is supported in a horizontal position so that the coalesced oil is largely confined to the apertures 230 of the upper back-up plate 280.

It is contemplated in appropriate applications and in modified structures, that the oil separator 232 can be mounted in other than a horizontal position, or that the normal flow of compressed fluid can be reversed so that coalesced oil collects on the underside of the separator 232 and the reverse regenerating flow purges the coalesced oil upwardly through the separator instead of downwardly. In any event, the surface tension of the coalesced oil is sufficient under most operating conditions, to maintain the coalesced oil on the normally downstream side of the separator without dripping. Where a perforated or other foraminous backing member is employed on the normally downstream side of the separator, the perforations and the imperforate surface of the backing member offer additional oil-collecting surface irrespective of the position of the separator.

Periodically the compressor is stopped and the exhaust valve 212 is opened, whereupon the almost explosive outrush of compressed fluid from the intermediate plenum 238, the chamber containing the desiccant material 208, and the space 286 between the lower filter pad 234 and the oil separator 232 forces the coalesced oil back through the filter disc 234 and through the apertures 230 of the lower or normally upstream plate 282, and out of the container 200 as denoted by flow arrows 290. In the case of a compressor in proper operative condition, the volume of coalesced oil is seldom sufficient to fill the apertures of the upper back-up member 280 so that the upper surface of the normally downstream back-up member 280 is not wetted by the coalesced oil and likewise there is little or no possibility of wetting the adjacent inner wall portion of the inner shell portion 214. However, with poorly maintained compressors which pass excessive quantities of lubricant, the entire or upper or normally downstream surface of the oil separator 232 can be completely covered with oil which coalesces on the solid parts of the separator between the apertures therein or within said apertures and the separator can still be properly regenerated by the high volume reverse purge flow. Thus, the separating space 286 prevents the coalesced oil from travelling with the incoming fluid stream to the desiccant material, and the coalesced oil is substantially completely removed from the oil separator during the initial portion of each regenerative interval.

When the aforementioned compressor has restarted or when incoming compressed fluid is otherwise admitted to the container 200, the oil separator is again immediately available for removing oil contaminants.

During the remainder of each regenerative interval and after the initial outrush of compressed fluid from the chambers 238, 286, and that containing the desiccant material 208, fluid exiting through the reverse bleed aperture 254 of the check valve 256 continues to flow through the chamber containing the desiccant material 208 until the desiccant material is regenerated, at which time the compressing interval of the operating cycle is reinstated.

The oil separator 232 and desiccant 208, then, essentially are regenerated in sequence. The momentary pressure drop which occurs across the oil separator 232 when the dump valve 212 is opened quickly regenerates the oil separator 232, whereupon the relatively slower regeneration of the desiccant material 208 commences. At this time regenerative fluid is conveyed from the upper plenum 242 through the differential fluid control means, including the reverse bleed check valve 250, and through the desiccant material as denoted by flow arrows 278. This flow is substantially at the discharge pressure of the dump valve 212.

It will be seen that the desiccant, the oil separator means 232, the oil separator regenerating means including the chamber containing the desiccant material 208 and the chambers 238, 286 and the desiccant regenerating means including the upper plenum 242, are all contained within a single container 200 so that the number of external plumbing connections within the system are minimized. The components of the compressing and drying apparatus which are thus contained within the container 200 can be quickly and easily installed or removed as a single unit of the system. The use of the sealing ring 227 in addition to its functions described previously also reduces the amount of vibrational or other shock forces transmitted to the cartridge 214 from the outer container 200.

If desired, a number of brackets 292 can be secured to the outer wall surface of a container 200 for mounting purposes.

Referring now to Fig. 5 of the drawings,

another arrangement of the oil separating means is illustrated therein. It will be understood, of course, that the oil separating means according to either Fig. 1 or 5 can be utilized in other apparatus than that shown, as long as the system in which the oil separating means are utilized is subjected to periodic flow reversals of the character which will purge the coalesced oil in the manner described.

In the modification of Fig. 5, a pair of oil separators 294 and 296 are spacedly mounted adjacent the lower end of cartridge 214′. The oil separators 294, 296 are spaced from one another and from the lower filter pad (not shown in Fig. 5) or other system component with the result that the spaces 286′ and 298 prevent oil communication respectively therebetween. The lower oil separator 294 is generally similar to the upper separator 296 and both are constructed substantially in the manner described above in connection with the oil separator 232 in connection with Figs. 1 and 4. Desirably, the filter disc 300 of the upper separator 296 is provided with a smaller pore size than the lower filter disc 302. With this arrangement, the proportion of removed oil is progressively increased, although it will be understood that the filter discs 300, 302 can be identical depending upon the application of the invention. If desired, additional oil separating means (not shown) can be mounted in a similar manner in series with the oil separators 294, 296 and spaced therefrom and from an adjacent system component (not shown) as set forth in connection with the lower filter pad 234 of Fig. 1.

From the foregoing it will be apparent that novel and efficient forms of desiccant towers, regenerating systems therefor, and combined refrigeration-desiccation drying systems have been disclosed herein. Although the systems have been described primarily for use with air, it will be apparent that the apparatus can be readily adapted for use with other gases. While we have shown and described certain presently preferred embodiments of the invention and have illustrated presently preferred methods of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practised within the scope of the following claims.

WHAT WE CLAIM IS:—

1. Gas drying apparatus incorporating a container, an inlet for gas to be dried and an outlet for dried gas, a first compartment located within said container between said inlet and outlet to hold desiccant material in the path of the gas flow, a second compartment located within said container downstream of said first compartment and adjacent said outlet, an exhaust valve provided in the container wall upstream of the first compartment, a check valve interconnecting said first and second compartments and adapted to close when said exhaust valve is opened and a passage which by-passes said check valve.

2. Apparatus as claimed in claim 1, wherein the by-pass passage is formed by a reverse flow aperture embodied in the check valve.

3. Apparatus as claimed in claim 1 or claim 2, wherein a filter for removing oil is located within the container upstream of the first compartment and wherein the exhaust valve is operable to discharge explosively compressed gas from within the container to eject oil droplets collected by said filter.

4. Apparatus as claimed in claim 3, wherein said filter, said first compartment and said check valve are all incorporated in a cartridge insertable in an outer container casing or shell to define an annular flow passage or plenum around said cartridge and within said container, and wherein the container inlet is disposed towards that end of the annular flow passage or plenum remote from the filter inlet end of the inserted cartridge.

5. Apparatus as claimed in claim 3 or claim 4, wherein said filter includes a relatively thin filtering member and a pair of foraminous backing members coextending with said filtering member and sandwiching said filtering member therebetween.

6. Apparatus as claimed in claim 5, wherein said backing members are apertured and the apertures thereof are respectively aligned to provide immediate contact of said filtering member by said gas.

7. Apparatus as claimed in any of claims 3 to 6, wherein at least two filters are spacedly mounted in tandem upstream of the first compartment on the gas flow path.

8. Apparatus as claimed in claim 7, wherein the filtering members of said filters are of progressively finer porosity in the direction of gas flow from the inlet to the first compartment.

9. Apparatus as claimed in any of claims 3 to 8, wherein a cup is positioned in the first compartment to catch and retain foreign matter in said reverse flow.

10. The combination of apparatus as claimed in any preceding claim with a compressor connected to the inlet, a storage tank connected to the outlet and a control arrangement operable to open and close the exhaust valve in response to the pressure in the storage tank to maintain said pressure within predetermined limits.

11. The combination as claimed in claim 10 as dependent upon any of claims 3 to 9, wherein the apparatus is positioned so that the filter is substantially horizontal, the gas flow into the first chamber is upwardly

through said filter and the flow from said first chamber is downwardly through said filter.

12. Gas drying apparatus substantially as hereinbefore described with reference to the accompanying drawings.

13. The combination as claimed in claim 10, substantially hereinbefore described with reference to the accompanying drawings.

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1213572 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

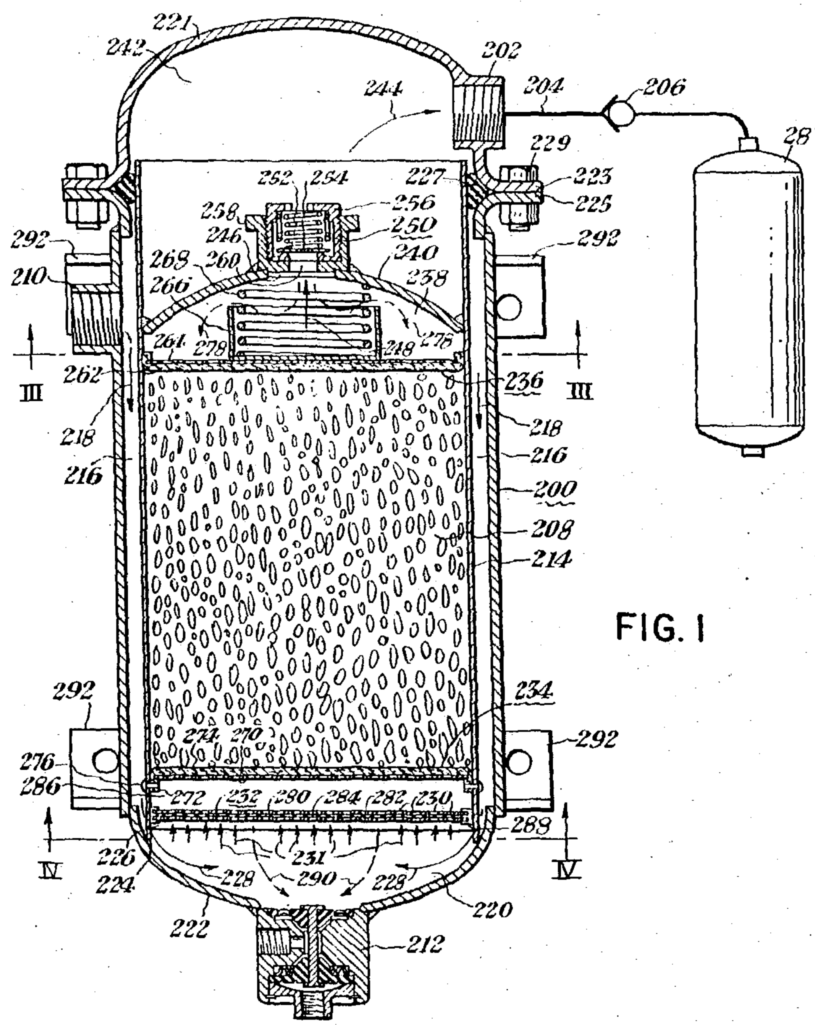

FIG. 1

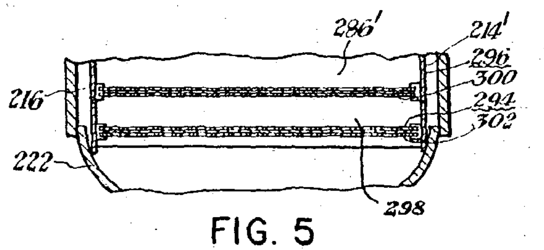

FIG. 5

1213572. COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

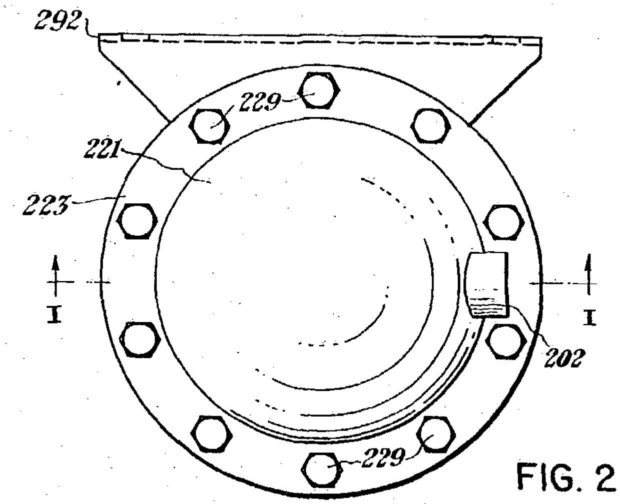

FIG. 2

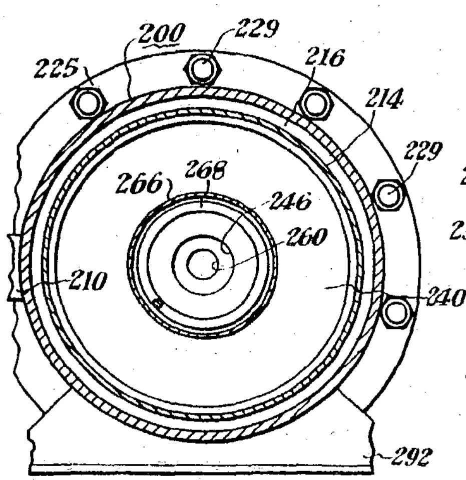

FIG. 3

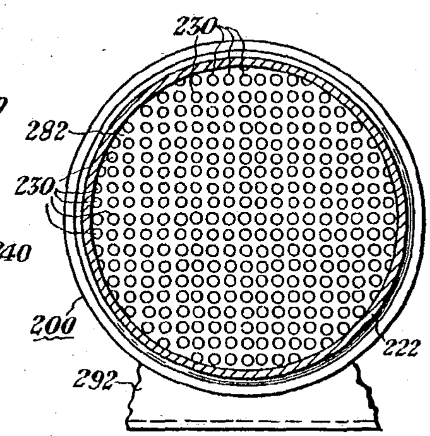

FIG. 4